Joint Transportation Research Program

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Cost-Effectiveness of Converting Signalized Arterials to Free-Flow Facilities

Introduction

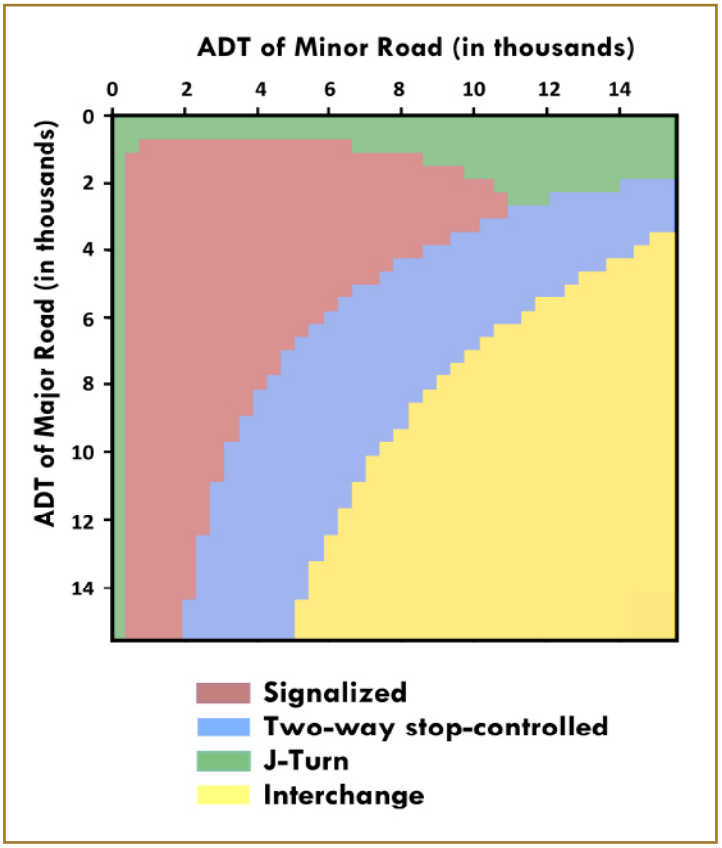
On four-lane divided signalized arterials, traffic signals pose a significant impediment to mobility. They often cause traffic congestion, driver frustration, decreased safety, and overall higher costs to highway users, the environment, and the economy through higher operating costs, emissions, and shipping delay. This research study examined the economic feasibility of converting existing signalized four-lane divided highways into free-flow corridors, where intersections with traffic signals are removed and redesigned as interchanges, J-turns, or other types of intersections. This study identified the conditions under which such conversion is cost effective and the threshold traffic volume at which converting a signalized arterial to a free-flow facility can be considered superior to doing nothing.

The developed decision framework addresses these questions by evaluating the overall performance of several corridor upgrade alternatives at two analysis levels: intersection and corridor. At the intersection level, four intersection alternatives were considered: signalized intersection (do nothing), two-way stop control (TWSC) intersection, J-turn, and interchange. The mobility and safety performance of the four alternatives were calculated, with the overall performance of an alternative measured in terms of the total life-cycle agency and user costs. This study was commissioned by the Indiana Department of Transportation to address this research need.

Findings

It was found that interchange always has the highest mobility performance. When traffic volume is very low, TWSC intersection has superior mobility performance compared to J-turn and signalized intersection. However, as traffic volume increases, delays at TWSC intersections increase significantly, while delays for the alternatives depend less on traffic volume. In terms of safety performance, interchange and J-turn are generally safer than the TWSC and signalized intersections. It was found that the overall performance of TWSC intersection is the most sensitive to traffic volume.

The study also established decision boundaries based on traffic level on the major and minor roads. Nomographs were developed to present the rankings of the alternatives under given traffic volumes and the



decision boundary at which the rankings of any two alternatives switch. It was found that, when the major ADT (average daily traffic) is less than 3,000 vehicles per day, the best option generally is TWSC. When the minor ADT is less than 4,000, J-turn is almost always more cost-effective than interchange, regardless of the major ADT. When the traffic volumes on major roads and minor roads are large enough, interchange is the best option. The nomographs can help the agency choose the appropriate intersection type based on the traffic volumes on both major and minor roads.

At the corridor level, the two conversion alternatives are free-flow corridor (with a mix of TWSC, J-turn, and interchanges) and freeway corridor (interchange only). Using corridor-level case studies, it was found that the freeway corridor plans are more beneficial to the users and have lower combined life-cycle equivalent uniform annual cost (EUAC) compared to the free-flow plans when agency cost and user cost are equally weighted. However, as a trade-off, the agency needs to spend much more on initial construction. Therefore, when agency cost is assigned greater weight, the freeway corridor conversion plans become very expensive and cannot compete with any other plan. The evaluation results are sensitive to traffic volume, corridor length, and the weight ratio of the agency cost to user cost dollar.

Implementation

This study developed a spreadsheet program to facilitate implementation of the decision support framework. This research product is designed to facilitate implementation of the study framework and results (that is, the decision support nomographs) to ascertain that they are appropriate and useful for the purpose for which they are intended. With the study product, INDOT is expected to be in a better position to support its decisions regarding corridor upgrades.

The intended primary user and implementor of the study is the Corridor Development Office of the Traffic Engineering Division of the Indiana Department of Transportation.

In the 2019-2020 period, the research and its associated decision-making support application have been invaluable to INDOT in evaluating (quantifying), confirming, and defending both corridor-level and site- or intersection-specific traffic control strategies, the latter including proper application of non-traditional or innovative intersection forms. The most notable of those uses were two 60- and 100-mile corridors in northcentral and northern Indiana involving $100 million plus investments. For those and several others, the research findings have guided the agency's evaluation, that is, in determining the most cost-effective level of overall traffic control, be it full freeway operation, a hybrid of select interchanges and at-grade intersections, free flow operation, or more conventional designs with prevailing traffic signal control.

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